Poster Abstract: *Resource Aware Placement of Data Stream Analytics Operators on Fog Infrastructure for Internet of Things Applications*

Mohit Taneja, Alan Davy
Telecommunications Software and Systems Group
CONNECT / The Centre for Future Networks and Communications, Ireland
Department of Computing and Mathematics
Waterford Institute of Technology
Waterford, Ireland
Email: {mtaneja,adavy}@tssg.org

***Abstract*— While cloud computing led the path towards a revolutionary change in the modern day computing aspects, further developments gave way to the Internet of Things and its own range of highly interactive applications. While such a paradigm is more distributed in reach, it also brings forth its own set of challenges in the form of latency sensitive applications, where a quick response highly contributes to efficient usage and QoS (Quality of Service). Fog computing, which is the answer to all such challenges, is rapidly changing the distributed computing landscape by extending the cloud computing paradigm to include widespread resources located at the network edge. While the fog paradigm makes use of edge-ward devices capable of computing, networking and storage, one of the key impending challenges is to determine where to place the data analytic operators for maximum efficiency and least costs for the network and its traffic, the efficient algorithmic solution to which we seek to propose by way of this work underway.**

Keywords—Fog Computing; Cloud Computing; IoT (Internet of Things); Analytics

I. Introduction

Cloud computing has seen significant growth over the past decade, generating a shift from distributed network paradigm to being centralized, with its core being the data centres of cloud service providers [1], [2]. Despite its advantages, the rapid increase in ubiquitous mobile and sensing devices which are connected to the Internet challenges the traditional network architecture of cloud computing framework. With IoT in play, we will have billions of interconnected heterogeneous devices emitting large volume of data streams for processing. In its survey, Gartner estimates 20.8 billion interconnected IoT devices by 2020, further substantiating the impending scenario [3]. IoT deployments generating huge amount of data will require it to be processed and analysed in real time. In such a scenario, transferring all the raw data to cloud for analysis is neither scalable nor suitable for real-time decision making. To meet the dynamic scalability, efficient in-network processing and real-time low latency communication, the need for IoT applications has led to the evolution of fog computing paradigm [4], [5]. This new computing paradigm extends the cloud utility computing to the edge of the network, resulting in latency reduction in communication and providing real-time data processing and dispatching.

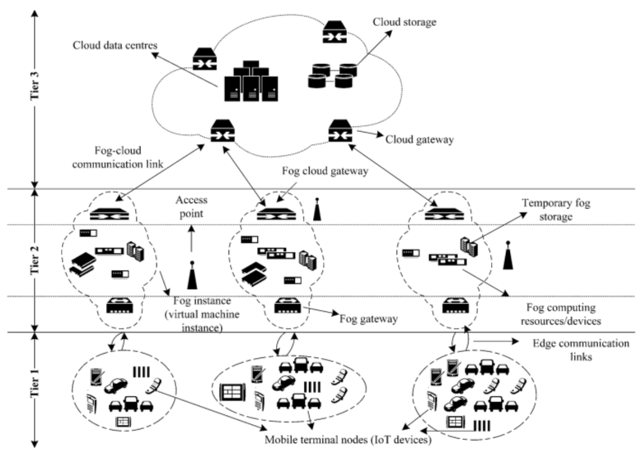

Fig. 1. Fog Computing Architecture

Building upon the work of Gupta et al. [6] in press, here we present the empirical results of our work in progress on developing a resource aware placement algorithm to place data analytics service to run either on cloud or the fog. While this work is still in its budding stages, the algorithm to be proposed is based on edge-ward placement of computing nodes, and would be in lines of a greedy or static heuristic resource aware placement. With this, in the near future, we aim to validate and propose a three stage optimal placement strategy: 1. Eligible node selection, 2. Instantiating a service on a specific node, 3. Optimal placement strategy search (based on various parameters such as SLA (service level agreement), time to receive data, processing cost, priority, etc.).

II. Fog Computing – System Overview

Firstly, a general fog computing architecture can be modelled as a three tier hierarchy [5] as shown in figure 1. In the architecture, IoT devices generating raw data are placed at the bottom-most tier (Tier 1). This tier sends the observed values to the upper layers via gateways for further processing and

978-1-5090-3322-5/16 $31.00 © 2016 IEEE
DOI 10.1109/SEC.2016.44

TABLE I. EXPERIMENTAL CONFIGURATIONS

	UpBw (Mbps)	DownBw (Mbps)	RAM (MB)	MIPS	Rate/MIPS
Cloud	100	10000	40960	20000	0.001
ISP Gateway	10000	10000	8192	4000	0.0
Fog-0	10000	10000	4096	2000	0.0
Fog-1	10000	10000	4096	2000	0.0

Between		Latency (ms)
Cloud	ISP Gateway/Proxy	200
ISP Gateway/Proxy	Fog-Nodes	3
Fog-Nodes	Sensor	1
Fog-Nodes	Actuator	4

filtering. The middle tier (Tier 2) is the fog computing layer, also referred to as fog/edge intelligence. It consists of devices such as router, gateways etc. The fog devices are connected to the cloud framework, and send data to cloud periodically. The third and the upper-most layer (Tier 3) is the traditional cloud computing layer corresponding to the cloud intelligence.

Fog computing involves component of an application running both in fog layer as well as on cloud layer, benefiting from edge device's close proximity to the end points. It also leverages on-demand scalability of cloud resources with its own infrastructure, and facilitates management and programming of computation, networking and storage services between the cloud data centres and the edge/end devices.

III. EXPERIMENT AND RESULTS

The focus being to study fog computing from the networking perspective, the main aim of this experiment was to study the network cost in a fog computing architecture in a simulated environment. The simulation was built upon iFogSim : a toolkit developed by Gupta et. al [6] over the CloudSim framework [7] for modelling and simulating IoT, edge and fog computing paradigm. The said project was worked upon in Eclipse SDK 4.6 version Neon, running on Intel^{R} Core^{TM} i7-5500U machine with 16 GB RAM and CPU @ 2.40GHz. For the experiment, we used two setups- one with two end devices per fog node in the network, and the other one with four. While an IoT device has been simulated by considering it as to be a sensor-actuator pair, the total number of such devices thus configured in the network were 4 and 8 respectively. The cloud stands at the core of the network, followed by the ISP Gateway / Proxy Server in the hierarchy below. The configuration used for the simulation has been summarized in Table I, and the corresponding summary of results obtained in Fig. 2. As expected, we can see the drastic reduction in network traffic with the application of the fog computing approach, and the energy consumption of the key nodes in the network. Fog based execution substantially saves the bandwidth cost and energy consumption inside the Internet backbone.

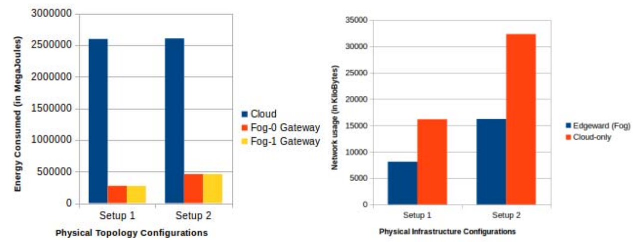

Fig. 2. Experimental results: (a) Energy consumed (b) Network usage

IV. CONCLUSION AND FUTURE WORK

We have presented here the empirical results obtained from the early version of the service placement algorithm. While the results forecast the algorithm to be building up in the intended way with the experiments yielding a positive shift by decongesting the network, what needs to be seen next is the priority aware resource management strategies in order to further optimize the scenario for denser and dynamic networks. We plan to conduct further evaluations on the scheduling policies with a testbed with flexible degree of replication to conclusively state the algorithm to work for real-world performance evaluation.

ACKNOWLEDGMENT

This work has emanated from research conducted with the financial support of Science Foundation Ireland (SFI) and is co-funded under the European Regional Development Fund under Grant Number 13/RC/2077.

REFERENCES

[1] Q. Zhang, L. Cheng, and R. Boutaba, "Cloud computing: State-of-the-art and research challenges," *J. Internet Serv. Appl.*, vol. 1, no. 1, pp. 7–18, 2010.

[2] N. Fernando, S. W. Loke, and W. Rahayu, "Mobile cloud computing: A survey," *Futur. Gener. Comput. Syst.*, vol. 29, no. 1, pp. 84–106, 2013.

[3] Gartner, "Gartner Internet of Things Prediction," 2015. [Online]. Available: http://www.gartner.com/newsroom/id/3165317#.

[4] F. Bonomi, R. Milito, J. Zhu, and S. Addepalli, "Fog Computing and Its Role in the Internet of Things," *Proc. first Ed. MCC Work. Mob. cloud Comput.*, pp. 13–16, 2012.

[5] I. Stojmenovic, "Fog computing: A cloud to the ground support for smart things and machine-to-machine networks," *2014 Australas. Telecommun. Networks Appl. Conf. ATNAC 2014*, pp. 117–122, 2015.

[6] H. Gupta, A. V. Dastjerdi, S. K. Ghosh, and R. Buyya, "iFogSim: A Toolkit for Modeling and Simulation of Resource Management Techniques in Internet of Things, Edge and Fog Computing Environments," pp. 1–22, 2016.

[7] R. Buyya, R. Ranjan, and R. N. Calheiros, "Modeling and Simulation of Scalable Cloud Computing Environments and the CloudSim Toolkit : Challenges and Opportunities," pp. 1–11, 2009.